

A Medicare Analysis of Spinal Cord Stimulator Therapy Removals Across the United States

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INTRODUCTION

BACKGROUND

Spinal cord stimulator (SCS) therapy has been established as an effective minimally invasive treatment for chronic pain that is gaining wider adoption in the United States. Removal of the SCS system has been associated with both postsurgical complications and poor efficacy. Specific reasons include surgical site infection, hemorrhage, development of immediate paraplegia, lack of long-term pain relief, electrode failure due to migration, and allergic reactions to hardware. Previous studies have indicated elevated rates of certain psychiatric disorders including anxiety, depression, posttraumatic stress disorder among patients post-removal.

GOAL

We aims to assess multiple socioeconomic/demographic factors potentially influencing SCS removal while also directly mapping which regions of the country have the most and least equitable access to allow for more nuanced understanding.

METHOD

Four unique open access databases were utilized to collect data: Medicare demographics, Medicare Advantage billing, US Census American Community Survey, and the USDA Atlas of Rural and Small-Town America. We combined data from these databases for the years 2017 to 2021. Python was utilized for database building and data cleaning. GeoDa5 (a statistical map-based graphing software) was used to plot and assess demographic, geographic, and socioeconomic trends.

STATISTICAL ANALYSIS

Multivariate logistic regressions were performed to assess and control for confounding variables. Cluster analysis was used to identify and prove statistical significance of complex spatial patterns of variables that could not be condensed linearly or logarithmically.

Moran's I, or global Moran's I, was used to measure the similarity of a FIPS area code to its neighbors. Spatial clusters that were identified were broken down into four groups of spatial outliers (High-High, High-Low, Low-High, and Low-Low) referencing the area's relationship with its neighbors. A local Geary was used to create a bivariate map for the cluster analysis.

Factorial ANOVA was performed to identify significant demographic variables within the cluster analysis groupings.

RESULTS

CLUSTER ANALYSIS

Between 2017 and 2021, 42,184 SCS have been removed in Medicare patients. Figure 1 is a Moran's I clustering analysis of the ratio of all Medicare billed SCS removals to SCS implantations per 10,000 Medicare members in their respective counties. For each county, the ratio of spinal stimulators removed to spinal stimulators implanted and a county-level Moran's I clustering analysis of that ratio is shown in Figure 1. Much of the map is gray, indicating that there is not a single instance of a SCS removal procedure billed to Medicare.

Among the counties that have had a SCS removed, there are less being conducted per 10,000 Medicare members across the East Coast, Milwaukee metro area, Miami metro area, and Central California, resulting in "cold spots." These "cold spots" are regions with a statistically significantly lower SCS removal to SCS implantation ratios, suggesting either a lower rate of negative outcomes or potentially limited access to SCS removal care. Relative "hot spots" are areas with a statistically significantly higher SCS removal to implant ratios, denoting communities that may have a higher rate of negative outcomes.

Figure 1:
Spinal Cord Stimulator Removals per 10k Medicare Members

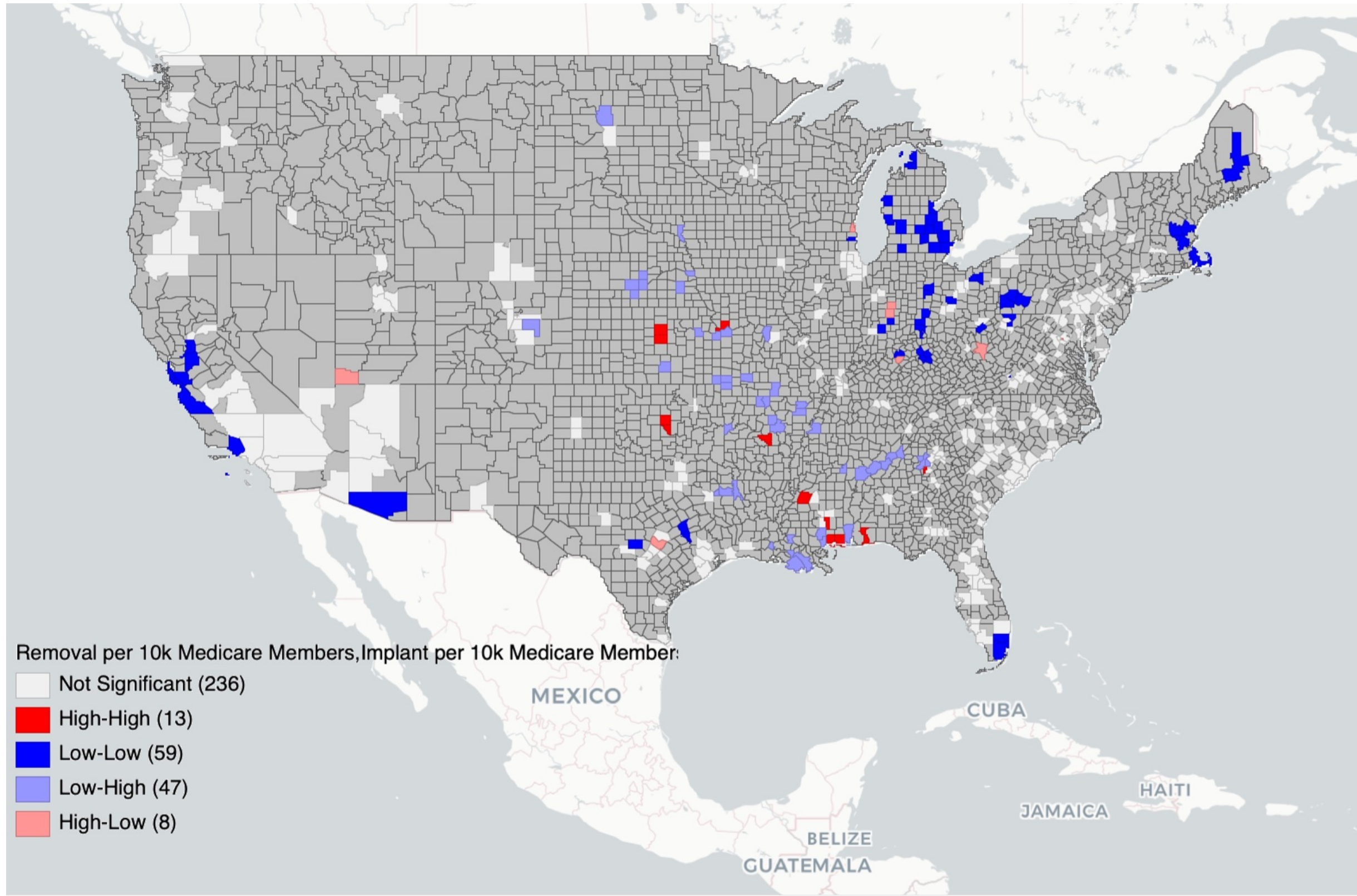


Table 1: Hotspot and Coldspot Analysis using Moran's Clustering on Demographics						
Variables	High-High		Low-Low		P-Value	Significance
	Average	SD	Average	SD		
Number of Counties	13		59			
Medicare Population	40413.32	31075.25	83700.15	94324.15	0.217	
Non-Hispanic White	0.68	0.26	0.80	0.21	0.083	
Black	0.19	0.17	0.06	0.07	0.081	
Hispanic	0.02	0.02	0.05	0.09	0.552	
2013 Rural-Urban Code	2.46	2.26	2.29	1.62	0.972	
Poverty	15.61	4.41	12.08	4.08	0.009	*
Median Household Income	53275.86	7902.41	67654.83	19602.68	0.002	*
Percent of adults with Bachelor's Degree	27.85	5.87	34.52	11.19	0.059	

Table 2: Hotspot and Coldspot Analysis on Spinal Cord Stimulator Procedures						
Variables	High-High		Low-Low		P-Value	Significance
	Average	SD	Average	SD		
Providers	40.05	19.16	59.10	19.42	<0.0001	*
SCS Removals	64.23	67.56	5.46	11.93	<0.0001	*
SCS Implants	280.85	299.46	64.71	73.93	<0.0001	*
Removal per 10k Medicare Members	6.26	9.88	0.10	0.22	<0.0001	*
Implantation per 10k Medicare Members	44.05	87.42	4.56	7.22	<0.0001	*
Ratio of Removal to Implantation	0.35	0.29	0.10	0.25	<0.0001	*

DISCUSSION

Our data supports existing literature noting that urban areas have better access to spinal cord procedures. However, our findings provide a more detailed understanding of the regional variation in SCS removals. SCS removal hot spot areas are located in the Midwestern/Great Plains region, with an average of 6 SCS removals per 10,000 Medicare members. Compared to cold spots—which have 0.1 SCS removals per 10,000 Medicare members—hot spots are more rural, have higher rates of poverty/lower median household income, lower rates of citizens with a college education, and a lower white population [Table 1]. Of note, SCS removal hotspot communities typically have fewer physicians, but much higher rates of implantation per 10,000 Medicare members [Table 2]. It is possible these communities serve as access points for surrounding communities without access to SCS care.

CONCLUSIONS

Expanding access to quality spinal cord stimulation therapy is imperative, particularly in light of the prevalence of chronic pain in the United States. Our data provides a visualization of the variation of SCS removals across the country and a statistical comparison of communities with high versus low rates of SCS removal. It is possible that the communities exhibiting highest rates of SCS removals may face challenges in accessing both advanced medical centers and fellowship-trained chronic pain specialists. Additional research could provide insights into the validity of this potential explanation. This data can guide future discussion and guide policy development in quality control of SCS implantations conducted in the identified hotspot communities, and increasing access to physicians who can conduct SCS procedures in rural communities.

REFERENCES

Sdrulla AD, Guan Y, Raja SN. Spinal Cord Stimulation: Clinical Efficacy and Potential Mechanisms. Pain Pract. 2018 Nov;18(8):1048-1067. doi: 10.1111/papr.12692. Epub 2018 Apr 23. PMID: 29526043; PMCID: PMC6391880.

Leiphart J, Barrett M, Shenai MB. Economic Inequities in the Application of Neuromodulation Devices. Cureus. 2019 Sep 17;11(9):e5685. doi: 10.7759/cureus.5685. PMID: 31720154; PMCID: PMC6823036.

Patel SK, Gozal YM, Saleh MS, Gibson JL, Karsy M, Mandybur GT. Spinal cord stimulation failure: evaluation of factors underlying hardware explanation. J Neurosurg Spine. 2019 Oct 4:1-6. doi: 10.3171/2019.6.SPINE181099. Epub ahead of print. PMID: 31585414.

Dupré, D. A., Tomycz, N., Whiting, D., & Oh, M. (2017, September 5). Spinal cord stimulator explantation: Motives for - Wiley Online Library. https://onlinelibrary.wiley.com/doi/full/10.1111/papr.12639

Julia Slyer, Samae Scott, Breanna Sheldon, Maria Hancu, Cheyanne Bridger, Julie G. Pilitsis, Less Pain Relief, More Depression, and Female Sex Correlate With Spinal Cord Stimulation Explants, Neuromodulation: Technology at the Neural Interface,Volume 23, Issue 5, 2020